

## SOME SCIENTIFIC CENTRES.

VIII.—THE MACDONALD PHYSICS BUILDING,  
MCGILL UNIVERSITY, MONTREAL.

WISE liberality has rarely reaped a richer and more immediate harvest than the gift by Sir William Macdonald of the Physics Building to McGill University at Montreal. This benefaction is but one instance—though a very important instance—of the fact that education, particularly scientific and technical education, is of enormous practical advantage, and that the most wealthy men in Canada and the United States recognise that it has the first claim on their generosity. In England money is given with no less lavish hand, but vast sums are devoted to objects less deserving than education, inasmuch as they afford palliatives, and not preventives, of failure, suffering, or distress.

The Physics Building, with its accompanying endowments and equipment both for instruction and research, forms but a small fraction of the total gifts of Sir William Macdonald to McGill University—gifts which exceed in value three and a half million dollars. A brief history of its growth, more particularly as a centre of research work, may be of service to those desirous of emulating a noble example.

In 1891 a chair of physics was endowed by Sir William Macdonald, to which John Cox, formerly Fellow of Trinity College, Cambridge, was appointed as the first professor. He was at once instructed to visit the best laboratories in America, and thus add to his experience of similar institutions in Europe. He received the most cordial assistance in the United States, and learnt both what to acquire and what to avoid. On his return, in conjunction with the architect, Mr. Andrew T. Taylor, he planned a building, beautiful in appearance, and so complete in every detail, that it is scarcely possible, with an intimate knowledge of the internal arrangements, to suggest any material improvements. The general scheme was to provide a building which would meet the requirements of the ensuing fifty years. The cost of the fabric was 29,000*l.*, being at the rate of about elevenpence a cubic foot.

The donor further instructed Prof. Cox to prepare estimates for equipment and apparatus, and in response for a request of 5000*l.*, the sum of 6000*l.* was placed at his disposal. At this point Sir William Macdonald decided to endow another chair for research in physics, and the institution was fortunate in obtaining H. L. Callendar, from Trinity College, Cambridge, as its first occupant. The equipment of the laboratory continued from 1892 to 1897, when the founder was assured that sufficient apparatus had been obtained; but the first grant had been greatly exceeded, and the total donation for this purpose was 22,000*l.* This sum has been discreetly spent, and adequate provision has been made for lecture tables, laboratories, and for all branches of physical research. Sir William Macdonald made a further gift of 30,000*l.* in order to secure an annual

income of 1500*l.* to provide for the salaries of demonstrators and to defray the cost of heat, light, upkeep of apparatus, and repairs to the fabric. As educational property is not subject to taxation in Canada, the only rate payable is the water tax. In addition to the preceding gifts, the donor of the Physics Building has made special grants from time to time for the purchase of radium, for a liquid-air plant, for two large induction coils, and in particular 1000*l.* for the purchase of books for the library in the building, and 400*l.* for a special research fund. It is fortunate that such splendid munificence has been judiciously expended by Prof. Cox, and that the results obtained have been such as to win for the laboratory a place in the foremost rank.

A detailed account of the rooms in the building is unnecessary, but an important item in the establishment is the workshop, with tools and lathes driven by electric motors, sufficient to make a large proportion of the more simple apparatus required for instruction or research. A complete plant of this



FIG. 1.—Macdonald Physics Building, McGill University, Montreal.

nature, under a competent mechanic and assistant, effects a great saving of time and money in a city where skilled labour is often scarce and always costly. It is not within the scope of this article to give an account of the purely educational uses of this building, but it is sufficient to state that the lecture theatres and laboratories are ample in size and equipment, so that all students in the faculties of arts and of science receive courses in physics suited to the requirements of their future professions. An interesting question arises as to the extent to which professors of research should devote their time to the instruction of ordinary students. On the one hand, it may be regarded as a waste of valuable time, but from the student's point of view it is a great gain to come into contact, both in laboratory and lecture room, with the best intellects in his university. A research professor must necessarily devote some of his time to the instruction of advanced students, and particularly to the assistance of research students. It is therefore undesirable that any large

fraction of his time should be absorbed by giving lectures to elementary students. This difficult question of the division of time appears to have been satisfactorily solved in the Physics Building.

The first research professor, H. L. Callendar, was an active and able investigator. He invented and improved his platinum thermometer with an ingenious compensation method, and applied it to various uses. In conjunction with Prof. J. S. Nicholson, of the engineering building, he solved many temperature problems connected with the steam engine. He investigated some important meteorological questions, determining the temperature at various depths in the earth—a matter of special interest during the severe winters in Canada. He also constructed a self-record-

heat of water at various temperatures. Dr. Barnes, with Dr. Coker, determined the effect of temperature on stream lines and the critical velocity. He has also made a close study of the properties and peculiarities of ice formation in Canadian rivers. Freezing does not occur merely at the surface, as in most English rivers, but, after passing rapids, water may congeal at the bottom and form "anchor ice." Still more remarkable is the formation of "frazil," consisting of minute crystals pervading the whole mass of water. The presence of ice in this state occasions serious trouble in the turbines of the power stations, and special precautions are necessary to mitigate the evil.

On the appointment of Prof. Callendar to the chair

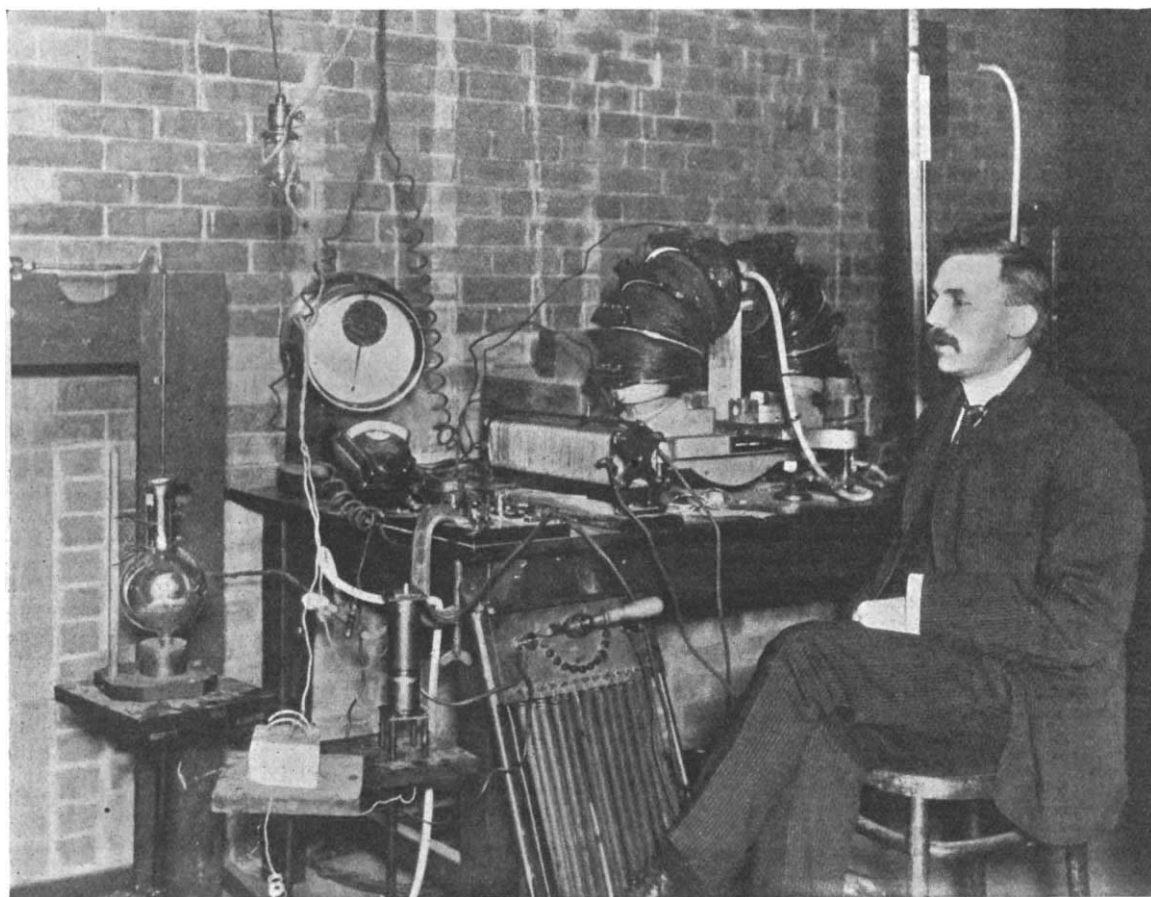


FIG. 2.—Prof. E. Rutherford, F.R.S., in his laboratory.

ing instrument which measured the difference of temperatures between the top of Mount Royal and the base near the observatory. Further results have been obtained by Prof. C. H. McLeod and Dr. H. T. Barnes, using the same instrument. The latter was also associated with Prof. Callendar in effecting some improvements in the Clark cell as a standard of electromotive force. But Prof. Callendar's most important work at McGill was the development, in conjunction with Dr. Barnes, of the continuous flow method of calorimetry. This has proved a great advance, both for simplicity and accuracy, on the older methods of calorimetry. Very exact determinations have thus been made by Dr. Barnes of the mechanical equivalent of heat, and of the specific

of physics at University College, London, Prof. Cox again visited the Cavendish Laboratory, and, on the advice of Prof. J. J. Thomson, he selected to fill the vacancy E. Rutherford, a young man who had already distinguished himself for originality, insight, and great capacity for work. Soon after M. Becquerel's discovery of the radiations from uranium, Rutherford had published a paper on that subject, and removed some misapprehensions as to the properties of the radiations. Moreover, he had served a most useful apprenticeship on the investigation of the properties of ions, whether produced by Röntgen rays, ultra-violet light, or by uranium. This thorough mastery of the indispensable elements served him in good stead when he continued at Montreal his



researches on radio-activity. At this time Prof. H. B. Owens, of the engineering building, had noted the peculiar inconstancy of the radiations from thorium, and traced it to air currents. Prof. Rutherford then made an exhaustive examination of the phenomena, and he found that thorium emitted a gaseous substance, to which he gave the name "emanation." He also proved that the emanation had the remarkable property of making other substances active by a material surface deposit due to the emanation. Assisted by Miss Brooks, he proceeded to measure the rate of diffusion of the emanation from radium, for he then saw and saw correctly, that the emanation was a gas and a distinct form of matter.

At this point Mr. Soddy came from Oxford to McGill University and worked with Prof. Rutherford. Together they tried the effect of varying the physical conditions, such as temperature, upon the emanating power of radio-active substances, and in the course of this work it was found that the emanation came from thorium X, a substance which could be separated from thorium. When they realised and clearly proved that the emanation was produced from thorium X, that thorium X constantly appeared from thorium, and as constantly decayed, that the curves of decay and of recovery were strictly complementary, and followed with exactitude simple exponential laws, that the rate of change was proportional to the amount of material still unchanged, then for the first time a most clear conception of the sequence of production of matter in fresh forms, with distinct chemical properties, was attained. The substances thus discovered were in quantities too minute to be detected by the balance or spectroscope. The new theory of radio-activity was published in two papers by Rutherford and Soddy in the *Philosophical Magazine* of September and November, 1902. In these papers the experimental evidence was first reviewed, and then the theory was stated that radio-activity is an atomic phenomenon accompanied by chemical changes in which new types of matter are produced, that the changes must occur within the atom, and that the radio-active substances must be undergoing transformation. This theory on its first appearance was regarded by many as a mere flight of the imagination, and efforts were made to detect a cause exterior to the atom. The theory was stoutly championed by Rutherford in the face of doubt and criticism, and it is now so thoroughly accepted by all who have investigated the subject that the initial opposition is almost forgotten. It is remarkable that a new subject should have reached the position of an exact science with such great rapidity.

Experimental research continued at McGill with speed which was almost feverish. Having established the fact that the highest temperatures obtainable had no effect on the rate of transformation of the emanation of radium, it was desired to try the effect of extreme cold. Again the good genius of the Physics Building was invoked, and a complete plant for making liquid air was presented. Within a quarter of an hour after the first 100 c.c. of liquid air were prepared the emanation had been condensed, and the material nature of this gas had been proved beyond question.

It is noteworthy that in the paper on the cause and nature of radio-activity in the *Philosophical Magazine* of November, 1902, the speculation was advanced that the presence of helium in minerals associated with uranium and thorium might be connected with their radio-activity. In 1904 this forecast was verified by the observation of the presence of helium in the spectrum of the radium emanation by

Ramsay and Soddy in the laboratory of the former. In the meantime Rutherford had proved by magnetic deflection that the  $\alpha$  particles carried a positive charge. The remarkable heating effects of radium, three-quarters of the total amount being due to the emanation, were investigated and measured. At a later date the heat generated by the  $\gamma$  rays was under observation and found to be very small, a result of importance in estimating the nature of the rays. In these heat determinations Prof. Rutherford was assisted by Dr. Barnes. In 1902 Mr. Soddy left McGill University, worked for a year with Sir William Ramsay, and was then appointed lecturer in physical chemistry at Glasgow University. Prof. Rutherford continued his research work with unabated energy and success. Radio-tellurium and polonium were relegated to their proper places among the products of radium, now grown to a family of six, the successive offspring of the emanation. The theory of rayless changes was advanced, and the complicated cases arising therefrom were thoroughly explored, and the results published in the Bakerian lecture delivered before the Royal Society in 1904. The brilliant work of Rutherford received recognition by the award to him of the Rumford medal. More recently he has again directed his attention to the  $\alpha$  particles, deflecting in electric and magnetic fields the rays from radium C and other substances, thus determining the charge and mass of the particles, and endeavouring to account for their abrupt disappearance whilst their velocities are still very great.

So much work and such novel theories have naturally called forth criticism, but the discussions have always been chivalrous, buttons have been on the foils, and Rutherford's extreme care in verifying every step by thorough experimental evidence has saved him from error to a degree quite exceptional. A prominent physicist in the early days of radio-activity remarked that the subject was such a tangled skein that it was almost hopeless to unravel it. This sufficiently indicates the difficulty of the subject in the initial stages. It is fortunate that so much of the development centred in a man to whom the remarkable instinct is given of rarely following side-issues. As a result of this concentration a uniform system of nomenclature has been adopted, and experimenters are saved much time and trouble in following the work of others. Apart from such concentration, it is not difficult to imagine the state of chaos into which the whole subject would have lapsed. Rutherford's work, "Radio-activity," has passed rapidly through two editions, has kept pace with discoveries, and is the encyclopædia of the subject.

At the physics building Prof. Rutherford inspires research students with some of his own enthusiasm and energy. He follows their results closely, is ready with advice and criticism, and is as delighted with any of their discoveries as with his own. He is generosity itself in giving a full measure of credit to those who do research work under his guidance.

Reference may be made to some of the work done by research students. Miss Brooks has published several papers on various radio-active phenomena, and this lady was one of the most successful and industrious workers in the early days of the investigation of the subject. H. L. Cooke discovered penetrating rays from the earth, and made contributions on the activity of ordinary matter. R. K. McClung determined the coefficient of re-combination of ions, and worked with Rutherford on the energy required to produce an ion, and on allied problems. S. J. Allan worked at the active deposit derived from the atmosphere and from falling snow. Miss Gates ascer-

tained the true nature of the discharge due to quinine sulphate. A. G. Grier detected the magnetic deviation of the  $\beta$  rays of thorium.

Others have come to Montreal from afar, attracted by the magnetic influence of Rutherford, such as Dr. Godlewski, of Lemberg, in Poland, who investigated in Montreal the products of actinium and some notable properties of actinium and uranium. From Frankfurt came Dr. Hahn, discoverer of radiothorium in the laboratory of Sir William Ramsay. Dr. Hahn, whilst working at McGill, also discovered radioactinium and a new product of thorium. Dr. Levin, from Göttingen, and Dr. Bronson, from Yale, have also done research work whilst at McGill, and the latter has increased our accurate knowledge of various radio-active constants by his modification of the electrometer giving direct and immediate readings. All these workers testify warmly to the inspiration kindled by Rutherford.

His own success as an investigator may be traced to a few well-marked characteristics. The first is the pertinacious and reiterated assault on the particular problem in hand. He does not grope in the dark for chance results, but bombards the particular point which he wishes to attack. He has also an instinctive insight which often makes his initial point of view more trustworthy than the deliberate conclusions of some befogged experimenter. He is not only an industrious, he is also a very rapid worker, but his experimental conditions are varied sufficiently to eliminate error, and his observations are repeated until he has perfect confidence in his results. Most noteworthy of all is the extreme simplicity and directness of his experimental methods. Some observers appear to grow happier as their apparatus becomes more complex. Rutherford selects some ingenious, straightforward attack, but the simplicity is supplemented by the genius which has enabled him to make such great contributions to our knowledge of the mutability of matter and of the atom in evolution.

In conclusion, the writer, who is an Englishman resident in Canada, ventures to emphasise the importance of research laboratories, so well equipped and so distributed that able men in Great Britain may not find themselves hampered through want of means and opportunity to pursue their work. The gift of the Cavendish Laboratory to the University of Cambridge by the late Duke of Devonshire has produced results which are recognised as holding the first place in recent advances in physical science. The Macdonald Physics Building has brilliantly started on its career. But there are other universities less fortunate, and there are other wealthy men.

A. S. EVE.

### THE YORK MEETING OF THE BRITISH ASSOCIATION.

#### PROVISIONAL PROGRAMMES OF THE SECTIONS.

THE local arrangements for this meeting, which will be held at York from August 1 to 8, are progressing extremely satisfactorily, and a large assembly is expected, as nearly 1200 persons from a distance have already signified their intention to be present. The evening meetings will be held in the large hall of the Exhibition Building; 2200 numbered seats are already arranged, while there is space behind, making up a total accommodation of at least 5000 if necessary. All these will have a full view of the speaker, and the lantern screen, though, of course, those behind will be a considerable distance away. It will be well, therefore, for visitors to bring their opera glasses with them.

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The neighbourhood of York affords many objects of interest, archæological, botanical, and geological, and many of these are more readily accessible by road than railway. Cyclists are therefore recommended to bring their machines with them, as the roads are mostly good and level. Hotel and lodging list can, as usual, be obtained of the local secretaries, Davy Hall Chambers, York. The following provisional programmes have been arranged by the committees of the various sections:—

#### SECTION A (MATHEMATICAL AND PHYSICAL SCIENCE).—

This section will, as usual in recent years, meet in three departments. In the chief department a series of discussions has been arranged. Prof. Soddy will open one on the evolution of the elements, and a number of leading workers in radio-activity, including Sir Wm. Ramsay, are expected to follow. Mr. J. Swinburne will discuss the nature of the radiation from incandescent mantles; and Dr. H. Rubens, of Charlottenburg, will expound his views, and illustrate them experimentally. Representatives of the Chemical Section will be deputed to attend both these discussions. It is expected that they will prove of great value as well as of great interest. The Hon. R. J. Strutt has consented to give an account of his recent work on the internal structure of the earth as indicated by the phenomena of radio-activity, and Prof. J. Milne will also speak on it. It is probable that the Geological Section will collaborate in this discussion; hence it will be treated from various points of view. There will be a paper by the Earl of Berkeley on osmotic pressure, which will lead probably to renewed debate on the ever-interesting subject of the nature of solutions. Sir Wm. Ramsay and J. F. Spencer have presented a paper on chemical and electrical changes induced by ultra-violet light, which contains important new matter, as well as a summary of what is at present known on this subject.

There will also be papers by H. Stansfield on photographs of thin liquid films (with experiments); Prof. E. H. Barton and J. Penzer on photographic records of a string's vibrations and responsive motions in the air; Mr. C. E. S. Phillips on the production of an electrically conductive glass; and Prof. W. F. Barrett on entoptic vision. In the Department of Astronomy and Cosmical Physics, a joint discussion has been arranged with Section E (Geography) on the necessity for the re-measurement of the British geodetic arc. This will be opened by Major E. H. Hills, R.E. In the Department of Mathematics, Prof. A. R. Forsyth will read a paper on the different kinds of integrals of partial differential equations. Papers will also be read on a test for the convergence of multiple series, by Mr. T. J. Bromwich; on some notes on finite groups, by Harold Hilton; on Aleph numbers, by Dr. E. W. Hobson; and on the residues of hyper-even numbers, by Lieut.-Colonel A. Cunningham. Prof. Henrici will open a discussion on the notation and use of vectors.

SECTION C (GEOLOGY).—The following are among the principal papers promised for this section: The problems of the Palæozoic glaciations of Australia and South Africa, Prof. J. W. Gregory; On a criterion of the glacial erosion of lake-basins, R. D. Oldham; Notes on recent earthquakes, Prof. J. Milne; On anthropods from the Coal-measures, Dr. Hy. Woodward; On the Jurassic flora of Yorkshire, A. C. Seward; Discussion on the origin of the trias, opened by Prof. Bonney and Mr. J. Lomas; On an artesian boring at Lincoln, Prof. Hull; On the post-Cretaceous stratigraphy of Southern Nigeria, J. Parkinson; On a peculiar variety of sodalite showing colour-change, T. H. Holland. Prof. P. F. Kendall will give a lecture on the geology of the country round York. The president's address will deal with the interglacial problem as it applies to the British Isles. A number of other papers have also been promised—relating mainly to the geology of the Yorkshire district. The following are among the number: On the limestone knolls of Craven, and on an intrusive rock near Grindleton in the West Riding, A. Wilmore; Notes on the glaciation of the Usk and Wye Valleys, Rev. W. Lower Carter; On faults as a predisposing cause of the potholes on Ingleborough, H. Brod-